Recurrence after varicose vein surgery: A prospective long-term clinical study with duplex ultrasound scanning and air plethysmography

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Objective: **We observed long-term venous ultrasound and plethysmographic changes after varicose vein surgery, to determine factors that influence recurrence.**

Methods and materials: **This observational sequential prospective study was carried out in an institutional referral center with day surgery. Subjects were 92 consecutive patients, ages 20 to 75 years, with symptomatic varicose veins in 127 limbs, who were able to complete regular assessment. Superficial varicose vein surgery included significant perforator vessels only, defined at preoperative duplex ultrasound scanning and air plethysmography. Similar follow-up assessments were performed at 3 weeks, 3 months, and 1, 3, and 5 years.**

Results: **At 3 weeks venous reflux but not muscle pump function was consistently improved in all limbs. However, inadequate surgery at the major junctions was clearly identified as contributing to recurrence of disease in 7.2% of limbs. Recurrence of varicose veins occurred in 1 of 100 limbs (1%) at the saphenofemoral junction and in 8 of 33 (25%) limbs at the saphenopopliteal junction. However, after 3 years disease recurrence at these sites had increased to 23% and 52%, respectively. Incompetent perforator vessels increased progressively in number. Clinical recurrence was 47.1%, and consistent with this was gradual deterioration in air plethysmographic measures of reflux, with physiologic recurrence (venous filling index, >2 mL/s) in 66% at 5 years. Late recurrence was predicted in limbs with multiple sites of reflux preoperatively, venous filling index greater than 2 mL/s, and some other persistent abnormality at duplex scanning at 3 weeks. There was no recurrence in 40 limbs in which these factors were normal at at 3 weeks. However, 29 of 53 limbs with normal venous filling index after operative intervention had deteriorated at 3 years.**

Conclusion: **Incomplete superficial surgery, in particular at the saphenofemoral and saphenopopliteal junctions, is a less frequent cause of recurrent disease, and neovascular reconnection and persistent abnormal venous function are the major contributors to disease recurrence. (J Vasc Surg 2003;38:935-43.)**

Varicose veins in the leg are exceedingly common, and surgery has been a mainstay of treatment. Patients with varicose veins make up a considerable portion of the surgical waiting lists in the major hospitals in New Zealand, a situation that has remained unchanged for many years.[1-3] This is compounded by recurrence of varicose veins, which accounts for more than 20% of those requiring surgery.[4] Despite many decades of skilled surgical experience and many variations in technical approaches, as well as numerous publications, the problem of recurrence of varicose veins has not changed.[5-8] Even though most agree on the necessity for accurate disconnection of groin tributary vessels at the saphenofemoral junction (SFJ), flush ligation, and stripping of the long saphenous vein, recurrence persists.[9-11] Some leave the incompetent perforator vessels to spontaneously regain competence; others insist that all incompetent perforator vessels must be disrupted. The causes of recurrence have largely been attributed to shortcomings in diagnosis, surgical technique, and debated pathophysiology.

The frequency of recurrent varices varies widely, influenced by research methods, clinical classification, diligence, surgeon or patient perspective, case mix, and diagnostic methods used. The advent of noninvasive vascular laboratory techniques such as duplex ultrasound (US) scanning and plethysmography has not only enhanced preoperative assessment for better varicose vein surgery, but has provided better tools for monitoring surgical outcome.[10,12-15] A few studies have reported early outcome with this approach, but there is no moderate or long-term prospective study of US-guided varicose vein surgery that describes the anatomic and physiologic changes that lead to recurrence.

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This study describes the 5-year follow-up of US-defined superficial vein surgery with air plethysmography and duplex US scanning. Changes are compared with clinical outcome to identify early predictors of recurrent disease.

METHODS

All patients requiring superficial vein surgery because of leg varicose veins at Dunedin Hospital were invited to participate in the study. Consenting patients were assessed clinically and then at the vascular laboratory with air plethysmography and duplex US scanning as part of the routine preoperative workup. Clinical disease severity was graded with the standard CEAP classification recommended by The Society for Vascular Surgery and the International Society for Cardiovascular Surgery.[16] All patients had symptoms, with CEAP class 2 or greater. Patient demographic data, duration of varicose veins, primary or recurrent status, time since initial surgery, type of operative procedure, and any history of deep venous thrombosis were recorded. The study was approved by the regional ethics review committee.

Whole-leg duplex US scanning with a 128 XP/5 scanner (Acuson, Mountain View, Calif) with a 7-MHz linear probe was performed as described.[17,18] Imaging of the thigh veins was performed with the patient in the 30-degree reverse Trendelenburg position. Popliteal and calf veins were scanned with the patient sitting. Reflux was defined as retrograde flow persisting for 0.5 seconds or more after manual compression or Valsalva maneuver. Incompetence in perforator vessels was defined as bidirectional flow with similar maneuvers. The deep and superficial systems were fully scanned from the groin down the whole lower limb. All named vessels were assessed and variants looked for. Deep to superficial communicating vessels were scanned for across the whole limb. Sites of reflux were videotaped for later review. The anatomy of varicosities was recorded on a pro forma venous mapping diagram. Each assessment was carried out by the same experienced group of vascular technicians.

Air plethysmography was performed with the technique described by Christopoulos et al.[19] Recordings were made with a digital multichannel system (MacLab/8; Analog Digital Instruments, Dunedin, New Zealand) connected to a computer (Macintosh Quadra 800; Apple Computer, Cupertino, Calif). Reflux was measured as venous filling time (VFT) and venous filling index (VFI). Calf muscle pump functions were measured with ejection volume, ejection fraction, residual volume, and residual fraction. Venous functional volume and venous outflow measured by maximum venous outflow and 2-second outflow ratio were also calculated. An ulcer index, defined as ratio of VFT to residual fraction, was used to evaluate the likelihood of developing ulcers.[20] VFI was measured with a variance of 10%. Physiologic recurrence was defined as VFI greater than 2 mL/s, and recurrence at US when significant reflux was observed for 0.5 second.[21]

All sites of reflux were mapped with US to direct the surgery, which was performed by a single surgical team in a day surgery setting. Procedures included flush ligation of the saphenofemoral junction (SFJ) or saphenopopliteal junction (SPJ), stripping of the long saphenous vein to the knee, and multiple avulsions. Only those incompetent perforator vessels with marked reflux were ligated; smaller vessels were left alone, in the belief that they would regain competency. No surgical correction of deep vein incompetence was carried out. No additional sclerotherapy for superficial vessels was used.

Within 2 to 3 weeks after surgery, air plethysmography and US were repeated to assess the adequacy of surgery. Where major reflux persisted and the patient agreed, surgery was rescheduled and completed. Thereafter all patients were followed up at the vascular laboratory at 3 months and 1, 3, and 5 years. Clinical progress and venous physiologic and anatomic changes were documented at each visit. At 3 months a standard patient satisfaction questionnaire for venous surgery used in the vascular laboratory was completed.

Clinical recurrence was defined as appearance of new varices not observed before surgery or reappearance of varices where they had been eliminated at surgery, or progression of signs of venous insufficiency, including ulceration, as observed by the clinician or reported by the patient.

Data were entered into a database (FileMaker Pro 2.1; Claris Corp) and transferred to an SPSS program (SPSS, Chicago, Ill) for analysis. The Student *t* test was used to compare measures of venous functions in various settings. Analysis of variance was used to distinguish significance for continuous variables. $P < .05$ was considered statistically significant. All values are given as mean ± SD unless otherwise noted.

RESULTS

Ninety-two patients were recruited, including 42 men and 50 women, mean age 53.9 ± 14.0 years. Disease was bilateral in 35 patients, in the right limb only in 23 patients, and in the left limb only in 34 patients. Of 127 limbs, 91 had primary varicose veins and 36 limbs had recurrent varicosities.

Severity of clinical insufficiency varied among limbs, including those with severe venous insufficiency (C_2 = 58, C_3 = 11, C_4 = 34, C_5 = 5, C_6 = 19). A variety of procedures were carried out, on the basis of US assessment, as shown in Table I. Venous function impairment and sites of reflux before surgery are shown in Tables II and III.

Initial outcome. At 2 weeks the planned surgery was shown to be successful in ligating the major junctions in 115 of 127 limbs (91%). Of 100 SFJ ligations, only one clearly failed, with demonstration of the intact SFJ; prompt re-exploration and ligation were carried out. After correction of the one missed SFJ, 85.8% of SFJ were absent and 8.3% were normal (Fig 1, *A*). No limbs had physiologically significant SFJ reflux at commencement of long-term follow-up.

Table I. Surgical procedures in 127 limbs with varicose veins

Procedure	*No. of limbs*
SFJ ligation plus thigh LSV stripping	70
SFJ ligation with no LSV stripping	21
SFJ plus SPJ ligation with or without thigh LSV stripping	9
SPJ ligation alone	24
Specific varicose vein avulsion	3
Additional incompetent perforator vessel ligation	37
Multiple avulsions to calf varicosities	127

SFJ, Saphenofemoral junction; *LSV,* lesser saphenous vein; *SPJ,* saphenopopliteal junction.

SPJ results at 2 weeks were less satisfactory, with inadequate surgery (ie, failure to obliterate the site of reflux) evident in 8 of 33 ligations (24%) (Fig 1, *B*). Reflux was still present at the SPJ, either continuing down the short saphenous vein or into refluxing gastrocnemius veins, or both.[22]

Deep reflux was present before surgery in 68 limbs (53.5%) with the Kistner classification. This was corrected at surgery in 39 of 68 limbs (57.4%). However, this occurred primarily in limbs with level 1 deep venous incompetence (reflux confined in the common femoral vein), which was corrected in 26 of 30 limbs (86.7%). This improvement was also seen in 7 of 17 limbs (41.1%) with segmental reflux (Fig 1, *C*). Major deep reflux, level 2 to 4, appeared to improve in some patients (6 of 21 [28.6%]).

Overall, the result of surgery based on US assessment was no detectable reflux at any site in 55 of 127 limbs (45.8%). The remainder all had some residual deep or lesser perforator vessel reflux left uncorrected by surgery.

The physiologic effect of surgery was significant, with improvement in all venous functions measured except for ejection volume (Table II, *A, B*). This was noted in most legs operated on, and normal VFI of less than 2 mL/min was achieved in 66% of limbs after surgery. Surgery was less effective in improving physiology of recurrent varicose veins compared with primary varicose veins (Fig 2, *C*). Those patients in whom recurrence subsequently developed during the study also noted less benefit immediately after surgery (Fig 2, *B*).

At 3-month follow-up, patient satisfaction was described as excellent in 47%, much improved in 43%, slightly improved in 3%, and not improved in 5%, and 2% of patients described the situation as worse.

Recurrence of disease. Clinical recurrence was progressive from 3 months onward (17 of 124 limbs [13.7%]), with most recurrent varices appearing in 36 of 114 limbs (31.6%) by 1 year and 60 of 116 limbs (51.7%) after 3 years, then changing little thereafter to 5 years (Fig 3, *A*). This rate was unaffected by age, gender, or side of limb. Progression of clinical recurrence was similar in patients with primary and recurrent varicose veins before surgery, at 49% and 55%, respectively, at 3 years. After surgery all ulcers healed and no new ulcers developed, but two ulcers recurred.

Corresponding to clinical changes, there was progressive deterioration in venous function tests over 5 years (Fig 2, *A*). This was most obvious in limbs in which clinical recurrence developed, but also occurred in the group without clinical recurrence (Fig 2, *B*). When recurrence is defined as abnormal VFI greater than 2 mL/s, then clinical recurrence at 5 years was noted in 66% of limbs (Fig 3, *B*). Limbs with primary varicose veins, although initially better after surgery (VFI, 1.57 ± 1.27 mL/s; VFT, 108.9 ± 57.6 s) compared with limbs with recurrent varicose veins (VFI, 2.16 ± 1.41 mL/s; VFT, 84.5 ± 47.4 s; $P < .0001$), showed similar deterioration and were no different after 3 years (Fig 2). There was no gender difference in recurrence rates, but patients with recurrent disease were older (57.1 ± 12.4 years) than those with VFI less than 2 mL/s at 3 years (49.1 ± 16.2 years; $P < .002$).

At follow-up after surgery there was also a corresponding increase in number of sites of reflux detected at US, most of which occurred between years 1 and 3 (Fig 1, *C*). At the SPJ and SFJ, all developing sites of reflux were recurrences, and none developed where normal competence was demonstrated at the start of the study. Of 100 SFJ adequately ligated, 23 (23%) demonstrated recurrent disease at 3 years, with most recurrence noted in the first year. Similarly, of 25 adequately ligated SPJ, 13 (56.6%) demonstrated recurrence, most between years 1 and 3. Consequently, half of the SPJ reflux at 5 years was the result of the initial incomplete surgery and half was due to formation of a new venous connection. Deep system reflux was largely unaffected. Limbs with incompetent perforator vessels increased in the first 3 months after surgery, from 49 limbs to 73 of 124 limbs (58.9%), then to 105 of 116 limbs (90.5%), mostly in years 2 and 3 (Fig 1, *A*). At 3 years only 8 limbs (6.9%) had no reflux detectable at US.

Prediction of recurrence. When recurrence is defined physiologically as VFI greater than 2 mL/s at 3 years, recurrence is more likely in limbs with worse preoperative venous function (Table II, *A, B*), and reflux present at three or more sites, compared with limbs without recurrence (44.6% vs 14.5%;, $P = .0016$). After surgery, correction to normal VFI was less frequent in limbs with recurrence (Table III), and complete absence of reflux at US was achieved less often than in limbs without recurrence (30.6% vs 62%; $P < .004$). Patients with recurrence were also more likely to have undergone SPJ surgery and were older.

More surgically relevant is clinical recurrence at 3 years, for which the only predictors were preoperative reflux at three or more sites and immediately postoperative an abnormal VFI or US-detectable reflux at 3 months (Table IV, *A*). Sensitivity, specificity, and accuracy of these postoperative measures to predict clinical recurrence are presented in Table IV, B. Lack of specificity of duplex US scanning was the result of the large proportion of limbs with some demonstrable reflux in perforator vessels without clinical manifestation. If both VFI and duplex US scans were entirely normal immediately postoperatively, no recurrences occurred. If there was some residual abnormality in

Table II. Physiologic measures after surgery

	VFI (mL/s)	*VFT (s)*	*Venous volume (mL)*	*Ejection volume (mL)*	*Ejection fraction*	*Residual volume (mL)*	*Residual fraction*
A. No recurrence							
Preoperative	3.3 ± 2.2*	60.8 ± 40.0*	135.0 ± 52.7*	64.4 ± 34.3	0.47 ± 0.16	58.7 ± 27.2†	0.45 ± 0.18
2 wk	1.1 ± 0.8*‡	131.0 ± 59.0‡	109.5 ± 40.6	60.8 ± 26.5	0.57 ± 0.19	31.7 ± 22.3‡	0.27 ± 0.17‡
3 mo	1.1 ± 0.7*‡	125.6 ± 52.5‡	110.6 ± 44.6	64.1 ± 30.6	0.60 ± 0.20	27.1 ± 19.2‡	0.24 ± 0.13‡
1 y	1.0 ± 0.5*‡	124.7 ± 52.6‡	109.4 ± 38.3	64.8 ± 28.0	0.59 ± 0.17	28.5 ± 20.8‡	0.27 ± 0.19‡
3 y	1.2 ± 0.4*‡	101.0 ± 39.1‡	114.5 ± 36.1	65.2 ± 26.2	0.58 ± 0.17	34.1 ± 21.2‡	0.30 ± 0.16‡
5 y	1.4 ± 0.6‡	84.1 ± 33.7	107.1 ± 35.2	60.3 ± 21.2	0.59 ± 0.20	35.7 ± 21.0	0.33 ± 0.22
B. Recurrence							
Preoperative	4.2 ± 2.0	47.7 ± 23.5	165.6 ± 48.2	71.6 ± 30.5	0.45 ± 0.17	79.7 ± 34.3	0.47 ± 0.16
2 wk	2.3 ± 1.4‡	75.5 ± 31.8‡	144.6 ± 43.4§	72.3 ± 27.8	0.51 ± 0.15	55.4 ± 29.9	0.37 ± 0.15‡
3 mo	2.5 ± 1.3‡	65.6 ± 23.7	143.4 ± 45.1§	69.9 ± 26.6	0.50 ± 0.17	52.7 ± 30.7	0.36 ± 0.17‡
1 y	2.9 ± 1.8‡	63.4 ± 28.5	145.4 ± 46.2§	74.1 ± 26.7	0.53 ± 0.19	53.4 ± 34.2	0.34 ± 0.18‡
3 y	4.3 ± 2.4	45.30 ± 15.9	154.9 ± 49.3	73.9 ± 32.2	0.49 ± 0.16	63.5 ± 34.2	0.40 ± 0.16§
5 y	4.4 ± 3.2	48.0 ± 22.9	152.2 ± 47.8	77.7 ± 38.1	0.51 ± 0.17	59.8 ± 30.2	0.40 ± 0.18

VFI, Venous filling index; *VFT,* venous filling time.
*$P < .05$, difference between recurrence and no recurrence.
†$P < .01$, difference between recurrence and no recurrence.
‡$P < .001$, difference from preoperative value.
§$P < .01$, difference from preoperative value.

Table III. Number of sites* of reflux at duplex scanning after surgery

	No recurrence (VFI ≤2 mL/s at 3 y; n = 62)								*Recurrence (VFI >2 mL/s at 3 y; n = 65)*							
	None		*Single site*		*Two sites*		*Three or more sites*		*None*		*Single site*		*Two sites*		*Three or more sites*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Preoperative	0		31	50.0	22	35.5	9	14.5	0		17	26.2†	19	29.2	29	44.6†
2 wk	36	62.1	15	25.9	5	8.6	2	3.4	19	30.6	23	37.1	14	22.6	6	9.7
1 y	23	44.2	23	44.2	5	9.6	1	1.9	7	11.3	18	29.0	23	37.1	14	22.6
3 y	7	13.0	33	61.1	12	22.2	2	3.7	1	1.6	21	33.9	22	35.5	18	29.0†

VFI, Venous filling index.
*Sites include saphenofemoral junctions, saphenopopliteal junction, lesser saphenous vein in thigh, perforator vessels, or deep venous system.
†$P < .05$, difference between recurrence and no recurrence groups.

both measures, clinical recurrence developed in almost all limbs (95%).

DISCUSSION

While results soon after surgery are pleasing to both the patient and the surgeon, clinical recurrence of 51% at 3 to 5 years is disappointing. This rate might well be criticized, but is consistent with other reports.[15,23-25] The recent report of a cohort of patients followed up with US for 34 years after SFJ ligation confirmed these high rates.[15] Similarly, the somewhat subjective observations of clinical deterioration in our study were also corroborated by the more objective measures of increasing sites of reflux shown at US and the number of legs with abnormal function at air plethysmography. Of particular importance, then, is knowing the contributors to this rate of recurrence and their relative importance. The high frequency might reflect case mix, but although the study included good numbers of patients with more severe disease and with recurrent varicose veins, neither of these factors resulted in worse outcome. The participants in this study group were older than in some other reports, and this may provide a bias, especially inasmuch as patients in whom recurrence developed, as measured by VFI greater than 2 mL/s, were significantly older.

The striking observation of this study is that recurrence occurred at sites where surgery had been clearly demonstrated as complete. There is still considerable opinion that inadequate surgery is the major cause of recurrence. This study casts doubt on this by showing that recurrence frequently occurs despite confirmation that surgery has been adequate. Assessment with US immediately after surgery provides effective quality control, which is strengthened with air plethysmography. Local surgical failure occurred in 7.2% of limbs. Surgery performed in the groin yielded better results. The possible variations of incomplete surgery in the groin have been well described by Royle.[26] In this study the SFJ remained intact, with direct connection to the lesser saphenous vein only once. While minor short duration reflux was detectable about the SFJ junction in 3 limbs at US, relevance to any later recurrence is not clear.

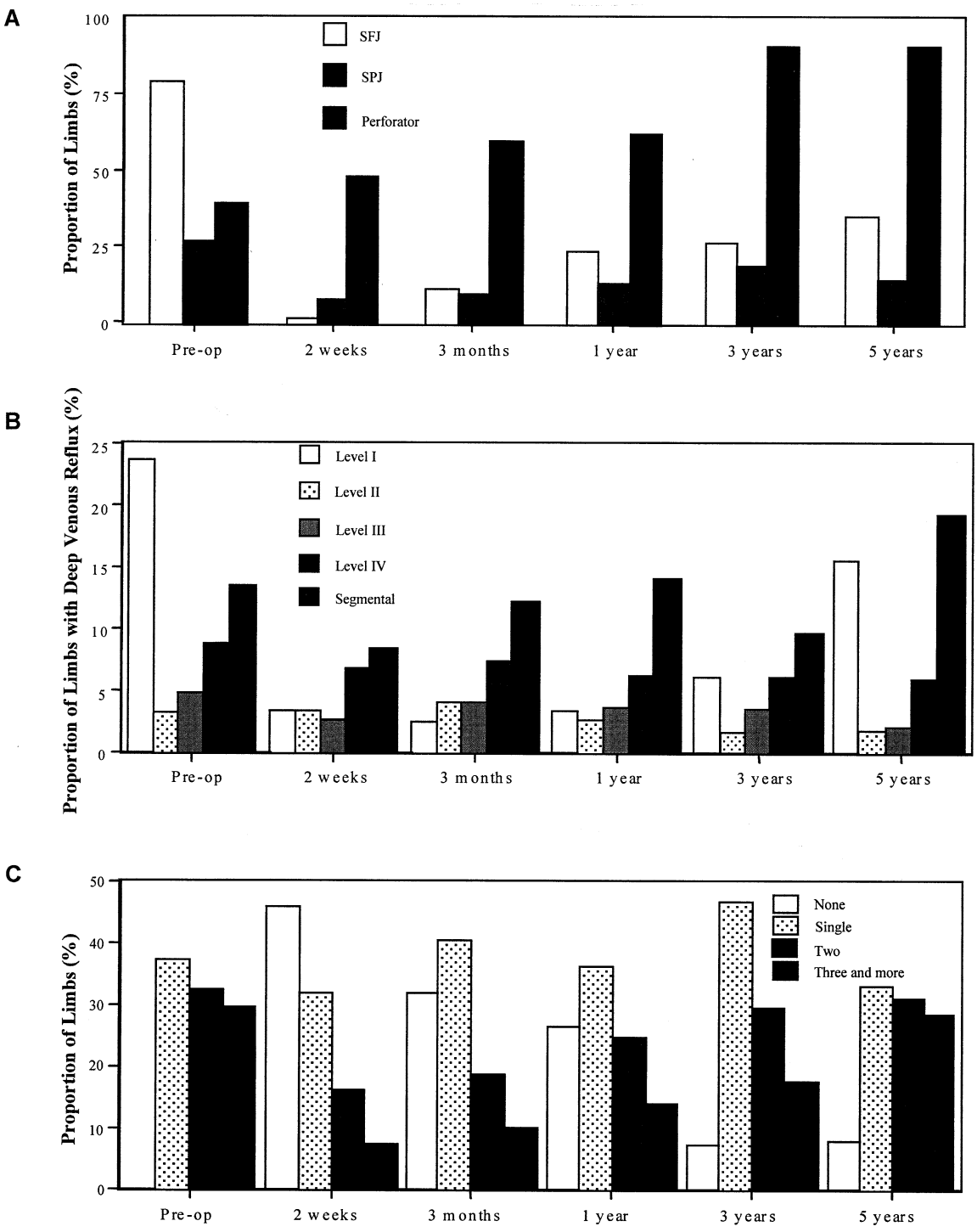

Fig 1. Changing patterns of reflux detected at duplex ultrasound scanning after surgery. **A,** Changes in sites of superficial reflux. **B,** Changes in level of deep reflux. **C,** Changes in number of sites of reflux.

The situation is far different for the SPJ, where despite US marking there was still 24.2% incomplete surgical disconnection of the SPJ. This was the most common cause of surgical failure. Difficulty in performance of SPJ ligation and high early recurrence is well recognized. The anatomy is complex and variable, with entry of large vessels near the SPJ. The Giacommini connection and medial gastrocnemius perforator vessel are significant confounders. Even

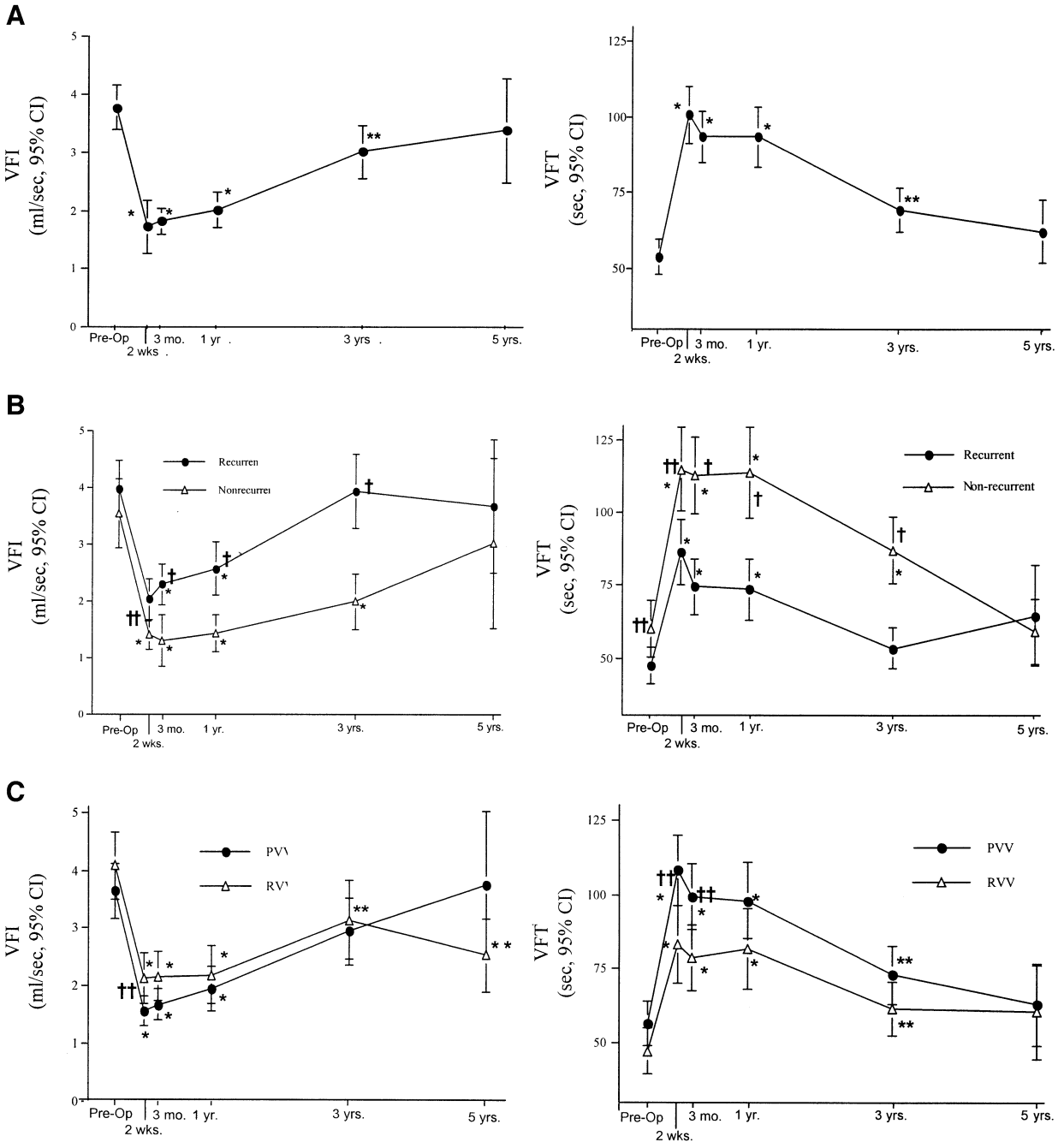

Fig 2. Changes in venous filling index *(VFI)* and venous filling time *(VFT)* after surgery. **A,** VFI for all limbs. **B,** VFI for recurrence (ie, VFI, >2 mL/s) or no recurrence at 3 years. **C,** VFI in limbs with primary varicose veins (n = 91) versus recurrent varicose veins (n = 36). *$P < .001$ and **$P < .05$, for difference from preoperative value; †$P < .001$ and ‡$P < .05$, for difference from other group at same time interval.

more detailed US description of the venous anatomic configuration in the popliteal fossa may be necessary for greater surgical confidence and better results.

However, these early surgical problems do not account for most recurrences at these sites. Where adequate surgery has been demonstrated, the recurrence rate is 23% at the SFJ and 52% at the SPJ. None of these were new sites of incompetence. This is good evidence for neovascularization as the commonest cause of recurrence at these sites. While neovascularization was once thought to be uncommon, it is being increasingly recognized as important.[8,27-29] The relative causes of US-detected recurrence

Table IV. Clinical recurrence of varicose veins

	No. of limbs	*Recurrence*	
		n	*%*
A. Recurrence rate determined by APG and duplex scanning at 2 weeks after surgery			
Normal VFI	79	29	37
Normal duplex	50	10	20
Both normal	40	0	
Abnormal VFI	42	38	91
Abnormal duplex scan	71	50	70
Both abnormal	37	35	95

	Accuracy (%)	*Sensitivity (%)*	*Specificity (%)*
B. Predictive value of APG and duplex scanning for recurrence			
APG	90	72	98
Duplex scanning	77	88	67
Both	80	61	97

APG, air plethysmography; *VFI,* venous filling index.

at the major junctions is summarized in Table V, which shows that neovascularization is observed in more than half of the limbs with clinical recurrence. More specifically, neovascularization accounts for 85% of recurrences at the SFJ and 62% of recurrences at the SPJ.

The effect of superficial venous surgery on deep reflux is interesting, and could be an unexpected additional benefit. It is not surprising that reflux in the common femoral vein (Kistner level 1) is largely corrected with SFJ ligation and that deep reflux to this level was more likely to reappear with SFJ recurrence. Others have reported similar findings.[30,31] Improvement of extensive deep reflux with superficial surgery alone and return of valve function is more remarkable. Instances occurred where deep reflux from the common femoral vein down to the calf veins was completely corrected. Further studies are required to confirm this benefit and to determine when this can be expected. Perhaps more important is that, unlike the gradual deterioration seen in the superficial venous system after surgery, further deterioration in deep venous reflux below level 1 was not observed over the 5 years (Fig 1, *B*).

The role of perforator vessels in varicose vein surgery has been debated for years.[32,33] There is the school of thought that advocates ligation of all incompetent perforator vessels. The equally vigorous view is that most perforator vessels should be left, because these will become competent after the major sites of reflux have been ligated. This study shows the latter view to be not true, because surgery was followed promptly with increased numbers of incompetent perforator vessels, which continued at 3-year and 5-year follow-up. At the end of the study, 90% of limbs had some incompetent perforator vessels, including limbs with no clinical or air plethysmography evidence of recurrence. This begs the question of whether a more aggressive approach to perforator vessels is required. Alternatively, it may mean that, no matter the surgery performed, the degenerative condition that underlies varicose veins inevitably continues or possibly is even worsened by surgery.

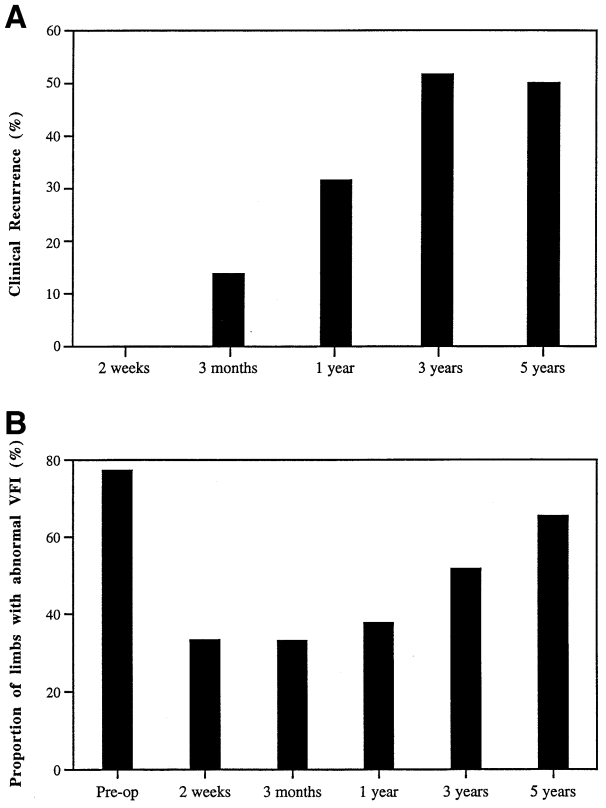

Fig 3. Proportion of limbs with clinical recurrence **(A)** and physiologic recurrence (venous filling index, >2 mL/s) **(B)** in the 5 years after surgery.

Another factor that must underlie varicose vein recurrence after surgery is the presence of the same factors that caused the original varicose veins. A continuing degenerative condition seems likely, in view of subsequent deterioration seen in venous physiology and the progressive increase in number of sites of reflux even after adequate surgical correction. Pertinent to this is that the gradual deterioration in the measures of venous reflux, along with increasing recurrence on duplex US scans was observed, even in limbs in which clinical recurrence had not yet occurred during the study. The factors that lead to this deterioration and to further incompetent perforator vessels, as well as reconnection at the SPJ and SFJ with neovascularization, are not known. That these phenomena do not seem to occur at other sites of venous ligation, or after SFJ disruption in femoropopliteal venous bypass grafting, suggests there is something unique in the lower limb with varicose veins.

The effect of superficial venous surgery on venous function is dramatic. Improvement in symptoms, early patient satisfaction, and conditions favoring ulcer healing are consistent results. Correction of major reflux improves all measures of function with the exception of the muscle pump, which, of no surprise, remains largely unaffected. While physiologic improvement was noted in all patients

Table V. Factors present in limbs with clinical recurrence

Factor	*% of Limbs*
At surgery	
Incomplete ligation	7.2
Untreated reflux (perforator vessels and deep system)	
Ultrasound	83
VFI (>2 mL/s)	58
After surgery	
New incompetence at SFJ or SPJ	0
Neovascularization	52
Additional incompetent perforator vessels	90

Uncorrected reflux is primarily residual deep reflux, incompetent perforator vessels, and distal long saphenous reflux not approached surgically, observed either at ultrasound or reflected in venous filling time immediately after surgery. Percentages exceed 100% because several factors may apply in a limb.

VFI, Venous filling index; *SFJ,* saphenofemoral junction; *SPJ,* saphenopopliteal junction.

after surgery, normalization of venous function was not always achieved. This is more readily achieved with primary varicose veins and, as might be expected, in limbs with physiologically less severe disease. This limitation of surgery was more common where there was residual deep reflux and persistent incompetent perforator vessels. Failure to normalize VFI was more likely to result in recurrence. To improve this outcome might require surgery to treat deep reflux in a relatively small group, but possibly a more aggressive approach to incompetent perforator vessels in a much larger group. The added benefits of such approaches still need to be determined.

In the meantime, studies such as ours may enable better prediction of which patients are more likely to do well over the 3 to 5 years after surgery. Case selection would be influenced by preoperative predictors, such as number of sites of reflux, previous venous surgery, and perhaps age. The better predictors of recurrence in this study were, however, postoperative assessments that defined the adequacy of the surgery. Consequently, in the limb with normal physiology and no US-detectable reflux after surgery recurrence is low. Conversely, if there is both residual reflux at any of the major sites assessed in the deep and superficial system at US and abnormal reflux at air plethysmography, clinical recurrence is highly likely. These latter limbs are a more complex group, in which other factors leading to recurrence are particularly relevant and need to be addressed. While surgical measures are important, such as careful dissection and identification at the sites of ligation, in particular the SPJ, and stripping of the long saphenous vein, other approaches should be considered.[10,11] For example, long-term external compression with stockings in the patient at high risk may be an important adjunct. Prevention of neovascularization remains a challenge. Local attempts to limit new vessel connections at the SFJ mechanically with fascial closure or a synthetic patch over the stump have been described, with mixed success.[34-37] Application of local inhibitors of angiogenesis or the new techniques of closure of the major venous junctions without incision of the vessels may have a role.[38] These may minimize wound vascular growth factor release and initiation of neovascular reconnection. The promise of early results of the rather costly radiofrequency and laser saphenous vein closure devices in preventing neovascular reconnection will require confirmation with longer term outcomes.[39,40]

In conclusion, despite successful surgical ligation of the sites of reflux varicose veins recur. This is contributed to by the underlying degenerative process of varicose veins, the disturbed venous physiology, and neovascularization, which at present are beyond control of the surgeon. Good outcome is more likely with simple disease in which immediately after surgery the VFI is normal and there are no sites of reflux at duplex US scanning.

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